Development Priority Zoning (DPZ)-led Scenario Simulation for Regional Land Use Change: the Case of Suichang County, China

Abstract: China has experienced an extraordinary level of economic development since the 1990s, following excessive competition between different regions. This has resulted in many resource and environmental problems. Land resources, for example, are either abused or wasted in many regions. The strategy of development priority zoning (DPZ), proposed by the Chinese National 11th Five-Year Plan, provides an opportunity to solve these problems by coordinating regional development and protection. In line with the rational utilization of land, it is proposed that the DPZ strategy should be integrated with regional land use policy.

As there has been little research to date on this issue, this paper introduces a system dynamic (SD) model for assessing land use change in China led by the DPZ strategy. Land use is characterized by the prioritization of land development, land utilization, land harness and land protection (D-U-H-P). By using the Delphi method, a corresponding suitable prioritization of D-U-H-P for the four types of DPZ, including optimized development zones (ODZ), key development zones (KDZ), restricted development zones (RDZ), and forbidden development zones (FDZ) are identified. Suichang County is used as a case study in which to conduct the simulation of land use change under the RDZ strategy.

The findings enable a conceptualization to be made of DPZ-led land use change and the identification of further implications for land use planning generally. The SD model also provides a potential tool for local government to combine DPZ strategy at the national level with land use planning at the local level.

Keywords: Development priority zoning (DPZ), Regional land use change, Prioritization of D-U-H-P, System dynamics (SD), Scenario simulation.

INTRODUCTION

As is well known, China has experienced a considerably surging economy in recent years. This is created many significant regional issues, such as excessive competition, industrial structure convergence and low efficiency (Charles, 2000; Fan, 1997; He & Zhu, 2007). Meanwhile, environmental degradation, deforestation, soil erosion and desertification is intensifying (MacBean, 2007; Rozelle et al., 1997; Wang, 2004). Similarly, the reduction in farmland, productivity losses and population growth has threatened China's food security - raising the question of 'Who will feed China?' (Brown, 1995). In order to balance regional economic development and environmental protection, the Chinese government promulgated the *Chinese National 11th Five-Year Plan*, introducing the Development Priority Zoning (DPZ) strategy (CPGPRC, 2006).

The DPZ strategy aims to specify the priority of development into optimal development, important development, restricted development and forbidden development. To operationalize this, it is proposed to zone most of China's counties into either *optimized development zones* (ODZ), *key development zones* (KDZ), *restricted development zones* (RDZ), and *forbidden development zones* (FDZ) (The State Council, 2010). This is to be done in line with local economic structures, future population structures, carrying capacity of local resources and environment, urbanization, and land use patterns (CPGPRC, 2006).

ODZ relates to regions with a high land development density and reduced resource and environment management capacity. Its main function is to improve the quality and benefits of economic growth, enhance global competitive advantage, and to maintain the region's role as the leader of national economic and social development. In contrast, KDZ concerns regions with good resource and environment management, relatively fast economic development and a well organized population agglomeration. The major function of KDZ is to improve business environment, boost industrial clusters, and promote industrialization and urbanization. In addition, it should accommodate the population transfer from RDZ and FDZ, and gradually become an important base for supporting national economic development and population concentration. RDZ, on the other hand, means that the region has a relatively weak resource and environment management capacity, reduced economic development conditions, and a poorly organized population agglomeration. The chief principle of RDZ is a "protection first, moderate development" with its principal function being to restore the ecological environment, moderately develop eco-tourism, eco-agriculture, and provide a balanced population density. Finally, FDZ refers to protected natural areas. The primary function of RDZ is to deliver compulsory protection, prevent contrived interference with the natural ecology, and prohibit any exploitation not conforming with the primary function (The State Council, 2010).

Many studies have been conducted exploring the positive effects of DPZ on development and planning systems. On the one hand, Xu (2006) found that DPZ could help improve the environmental ecology and promote economic progress in less developed regions.

Similarly, Sun & Zhu (2006) believe that DPZ provides a basis for formulating regional policies, appraising political performance, and offers an alternative approach to coordinating regional development. On the other hand, Gu *et al*. (2007) think that DPZ can combine regional spatial planning with national economic planning, which would alleviate the problems caused by (1) an extreme emphasis on the temporal planning of the economy and social development and (2) neglect of spatial planning (Fan, 2007). In this context, the DPZ strategy provides an opportunity for the central government to effectively integrate all the planning systems involved.

It has been suggested that the relevant polices concerning national finance, industry, land use, population and environment should match the strategy of DPZ, for otherwise DPZ cannot perform as well as expected (Wei, 2007). For instance, the DPZ should be closely integrated with regional land use, as land use management is a key policy instrument in China. Many researchers, therefore, have considered the relationship between DPZ strategy and regional land use. Liu (2007), for example, believes that the speed and intensity of D-U-H-P should be a main function of DPZ when formulating land use policy, with D-U-H-P representing the four land use categories of of land development (D), land utilization (U), land harness (U) and land protection (P). Likewise, there have been several other qualitative studies of policies supporting the four DPZ (e. g. Cao, 2007; RGLRINDRC, 2007; Zhang & Li, 2007).

This work, however, has mainly focused on the benefits of DPZ and the way that DPZ could align with land use policy. Little has been done to investigate the effects of DPZ-led land use change. Generally speaking, land use patterns are characterized by the way in which D-U-H-P is prioritized and different priority arrangements will clearly lead to different land use structures and spatial distribution when formulating land use planning (Shi et al., 2008). Of course, there are there are many possible prioritizations of D-U-H-P in theory, but the choice of these in practice is usually limited by temporal and special considerations as land resources are invariably limited. It is therefore necessary to prioritize D-U-H-P prior to formulating land use plans, particularly in the context of China (Liu & Yang, 2008). This is the primary motivation of this paper, which aims to explore the likely effects of DPZ on land use change through the use of System Dynamics in the selection of a suitable prioritization of D-U-H-P.

METHODOLOGY

System Dynamics (SD)

System Dynamics (SD) is a method of studying the dynamical behaviour of information feedback systems based on feedback-control theory (Zhou, 1988). It was first created by Forrest in 1956 in the form of a computer simulation model (Forrest, 1971) - centred on the notion that the *behaviour* of a system is mainly due to its *structure* (Jan, 2003), with system structure being identified by investigating material and information flows and their feedback (Chen et al., 2006). The SD method has subsequently been widely applied to the study of systems with complex, dynamic, and nonlinearly interactive variables in many fields, including land use systems (Wu et al., 2011).

Land use systems have obvious nonlinear dynamics characteristics, being interrelated with population, resources, environment, development and policy systems (Wu *et al*., 2004; Wu *et al*., 2011). Many studies have adopted SD to investigate land use change from the perspective of policies such as those concerned with economic development, sustainable development planning, and urbanization (White et al., 1997; He et al., 2005; Shen *et al*., 2009; Wu *et al*., 2011). Moreover, SD is able to simulate changes in the future is therefore effective in modelling the response to the demands of land use planning in China, as China's land use planning still emphasises the control of future land use.

Conceptual model of DPZ-led land use change

The first step in constructing a conceptual SD model is to define the system boundary. In terms of land use change, the interrelated aspects of land use D-U-H-P, population, resources, environment and development (PRED) comprise the main variables involved. This suggests that the SD model for land use change should have a boundary comprised of a land use system, together with development priority zoning (DPZ) strategy, population, resources, environment and development subsystems (Figure 1).

< Insert Figure 1 here >

In this model, all the subsystems are interrelated and interact. For instance, the DPZ strategy determines the prioritization D-U-H-P, which therefore affects land use change. The DPZ strategy also affects population, resources, environment, the development subsystems and land use system. This, in turn, results in construction, agricultural and ecological land use changes. Land use change is therefore specified as a quantitative distribution change in construction, agricultural and ecological land. The conceptual model involved will be further demonstrated as an SD model, discussed in the next section.

MODEL DESCRIPTION

The DPZ-led land use change system

The SD DPZ-led land use change system comprises of main land use system and five subsystems of population, resource, environment, development and DPZ strategy and focuses on the quantity of construction, agricultural and ecological land. The stock-flow diagram was demonstrated as shown in Appendix 2. The conversion speed among these is partly determined by the variables of the five subsystems and partly by the way in which D-U-H-P is prioritized, the details of which are as follows.

D-U-H-P Priority

As introduced earlier, land use management mainly focuses on land development (D), utilization (U), harness (H) and protection (P) (Lu, 2002) and hence the term D-U-H-P. The land use management practices in China, land use change, drivers and corresponding types of D-U-H-P are summarized in Table 1.

<Insert Table 1 here>

In order to measure D-U-H-P prioritization, four iterations of the Delphi method were used to collect opinions concerning D-U-H-P prioritization from various experts in the field of land use planning and management - including 10 experts from government departments and 15 from research & higher education institutions – and the Analytical Hierarchy Process (AHP) was used to obtain the results. These show the first, second, third, and fourth priorities to be 0.4, 0.3, 0.19 and 0.11 respectively. The consistency ratio (CR) of 0.01 indicates the results are sufficiently consistent (Zahedi 1986).

DPZ-led prioritization of D-U-H-P

Different DPZ are associated with different D-U-H-P priority rankings. The highest priority of ODZ, KDZ, RDZ and FDZ is essentially U, D, H and P respectively. This leaves three remaining land use categories yet to be prioritised, as listed in Figure 2.

<Insert Figure 2 here>

Prioritizing the three land use categories of the four DPZ was investigated by interviewing various experts in the field of land use planning and management, including 10 from government departments and 15 from research and higher education institutions. The outcome of this was to identify **UHDP** as the appropriate ranking of land use categories for ODZ. For KDZ, the ranking is **DUHP** in order to sufficient public infrastructure facilities and attract out-migrations from RDZ and FDZ to work and live. The ranking for RDZ is **HPUD**, while for **PHUD** is considered appropriate for FDZ.

DPZ strategy subsystem

The **DPZ Strategy** contains a decision subsystem to formulate supporting coordinated policies. To simplify the model, the subsystem selects population management, industry structure, fiscal and land use policy. In this context, various values of the associated indicators are used to reflect the different policies involved. This affects the natural growth rate of the urban and rural population, out-migration and in-migration in the **Population** subsystem represented by '*incentive for natural population growth'*, '*out-migration incentive'*, and '*in-migration incentive'*. It adjusts the growth rate of the primary industry GDP, secondary industry GDP and tertiary industry GDP, and fiscal transfer in the **Development** subsystem through incentives, characterized by '*incentive for primary industry GDP growth*' (abbreviate as *1 GDP incentive* in the relevant figure), '*incentive for secondary industry GDP growth*' (abbreviate as *2 GDP incentive*), '*incentive for tertiary industry GDP growth*' (abbreviate as *3 GDP incentive*), and '*fiscal transfer standard'*. Also, it decides the standard of '*urban construction land per capita'*, '*coefficient of dynamic balance in farmland*'[1], and '*coefficient of increasing vs. decreasing balance*'[2], which further affects land use change in the **Land use** subsystem.

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[1] 'Dynamic balance in farmland' is a Chinese land use policy stressing that farmland occupied for construction should be compensated through various means including reclamation of ecological land, rural construction land consolidation and agricultural land consolidation. 'Coefficient of dynamic balance in farmland' here represents the ratio of farmland compensation to those occupied for construction land.

[2] 'Increasing vs. decreasing balance' is a land use policy adopted by the Chinese government to balance the reduction in rural construction land with an increase in urban construction land. The 'Coefficient of increasing vs. decreasing

Most importantly, it prioritizes D-U-H-P as introduced above.

<u>The main land use system</u>

The main land use system focuses on the quantity of agricultural land, construction land and ecological land. The quantity is changed through D-U-H-P. There are eleven variables to represent land stock. '*Eco-fragile farmland'*, '*low-quality farmland', 'normal-quality farmland', 'good-quality farmland', and 'other agricultural land'* (all agricultural land except farmland) comprise agricultural land. Construction land is represented by the stock variables *'urban construction land', 'rural construction land', and 'other construction land'* (all construction land except for urban construction land and rural construction land). Ecological land is composed of the stock variables '*forest*', '*water*', *and* '*unused land*'.

Land development includes construction occupation and the reclamation of ecological land. Construction occupation is characterized by '*newly added construction land'*, which is the product of the *D* priority and the sum of '*newly added urban construction land'*, and '*newly added other construction land'*. Newly added construction land comes from farmland (represented by '*farmland occupied for construction*'), other agricultural land (represented by '*other agricultural land occupied for construction*'), ecological land (represented by '*ecological land occupied for construction*'), and rural construction land (denoted by '*urban sprawl*'). Farmland occupied for construction is compensated through various means, including rural construction land consolidation and reclamation of ecological land. The amount of farmland compensation is represented by '*farmland compensated for dynamic balance*', which is the product of '*farmland occupied for construction*' and '*coefficient of dynamic balance in farmland*'. 'Reclamation of ecological land' is the product of priority *D* and the difference of '*farmland compensated for dynamic balance*' and '*rural construction land consolidation*' as shown in Figure 3.

Land use priority *H* includes rural construction land consolidation and agricultural land consolidation. '*Rural construction land consolidation*' is the product of *H* and the '*coefficient of increasing vs. decreasing balance*' and '*newly added urban construction land*'. Agricultural land consolidation is determined by '*gap of farmland demand and supply*' and priority *H* as shown in Figure 3.

Land protection is represented by the conversion from farmland to forest, decided by '*incentive for fiscal transfer'* and priority *P*. It also leads to an eco-fragile farmland decrease and forest land increase as shown in Figure 3.

<Insert Figure 3 here>

<u>The Population, Resource, Environment and Development subsystems</u>

Population subsystem

Population growth generates increased demand for resources while an increase in urban

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balance' here denotes the ratio of the reduction in rural construction land to the increase in urban construction land.

population increases the demand for urban construction land. As a result, this subsystem is concerned with the number of people and their distribution over urban and rural areas. There are two stock variables involved, namely '*rural population'* and '*urban population'* that capture the critical aspects of this subsystem. '*Natural growth rate of rural population'* and '*Natural growth rate of urban population'* are affected by '*incentive for natural population growth'*. '*In-migration'* and *'out-migration'* are affected by '*in-migration incentive'* and *'out-migration incentive'*. '*Rural-urban migration'* is used to capture local urbanization, which is determined by the '*urban-rural income gap'* (Hou, 2004; Siciliano, 2012). Figure 4 shows the causal relationships involved in this subsystem.

<Insert Figure 4 here>

Resource subsystem

Land is one of the essential resources for human activities - to provide food, support socio-economic development, and protect the environment. The major problems associated with the land resource in China are insufficiency, low quality, desertion of farmland, and high occupation of good quality farmland by construction. Therefore, this subsystem focuses on farmland in terms of the quality of farmland and the amount of farmland needed for food security. For simplicity, farmland is divided into '*eco-fragile farmland'*, '*low-quality farmland'*, '*normal-quality farmland'*, and *'good-quality farmland'* according to its quality. A quality coefficient is used to compare the grades of these four types of farmland. The overall farmland quality changes, reflected by '*gap of farmland quality and the quality benchmark*', affects the growth rate of primary industry GDP. At the same time, farmland demand is controlled by *'total population'* and *'per capita farmland demand'*. The '*gap of farmland demand and supply*' drives agricultural land consolidation to compensate farmland. Figure 5 shows the causal relationships involved in the resource subsystem.

<Insert Figure 5 here>

Environment subsystem

In China's rapidly developing economy, large amounts of ecological land are being developed for construction, replacing old farmland and causing desertification and soil erosion, in exploiting the economic value of land at the expense of it ecological values. This subsystem, therefore, takes into account the ecological values of land. In doing this, the ecological values of agricultural land, forest, water, and unused land are calculated by multiplying the ecological values per hectare and land areas according to land type - the. ecological services per capita for different types of land being derived from Costanza et al (1997) and Xie et al (2003). The '*increase of per capita ecological services'* drives the fiscal transfer, which in turn reduces the increase rate of secondary and tertiary industry GDP, and finally the conversion from farmland to forest. In addition, the '*gap of forest coverage and coverage benchmark*' affects the quality of farmland. Figure 6 shows the causal relationships involved.

<Insert Figure 6 here>

Development subsystem
Social development plays an important role in China's rapid economic development. However, the inequality of public services is prominent among regions and urban and rural areas. Therefore, DPZ aims to balance regional development and achieve equality of public services among regions and between urban and rural areas. In response to this, the subsystem mainly focuses on economic and social development.

There are three stock variables involved, namely the primary, secondary and tertiary industry GDPs represented by '*1GDP*', '*2GDP*', and '*3GDP*' respectively, to capture the critical aspects of economic development. '*1GDP*' is determined by '*1GDP growth rate*' representing historical primary industry GDP trend, '*1GDP incentive*' denotes DPZ's industry policy, and '*gap of farmland quality*' characterizes the impact of farmland quality. Similarly, '*2GDP*' is determined by '*2GDP growth rate*' - representing secondary industry GDP trend, with *'2GDP incentive*' implying industry policy, and '*23GDP decline factor*' signifying the weakening impact of '*fiscal transfer*' on secondary and tertiary industry development in order to protect the environment. The dominant factors of tertiary industry GDP are similar to those of secondary industry GDP. In this case, '*rural per capita income*' is determined by '*1GDP*' and '*urbanization rate*' while '*urban per capita income*' is affected by '*2GDP*' and '*3GDP*'. The '*urban-rural income gap*', which is the difference between '*urban per capita income'* and '*rural per capita income*', also affects rural-urban migration within the population subsystem.

Auxiliary variable '*per capita expenditure on basic public services*' is used to represent the critical aspects of social development and contribute to the simulated impact of DPZ. '*Total expenditure on basic public services*' is the sum of '*expenditure on basic public services based on GDP*' and '*fiscal transfer*'. Figure 7 shows the causal relationships in the development subsystem.

<Insert Figure 7 here>

CASE STUDY

<u>Introduction to Suichang County</u>

Suichang County is in Lishui City of Zhejiang Province, which is located between north latitude 28° 13′ -28° 49′ , and east longitude 118° 41′ -119° 30′ as shown in Figure 8. It is upstream of Qiantangjiang River and Oujiang River with 88.83% of land area being rugged terrain. Therefore, Suichang County has a very important role to play in environmental protection and ecological security within Zhejiang Province.

<Insert Figure 8 here>

Suichang County occupies 254,572.66 hectares of land, with 27,215.62 hectares of agricultural land, 3,282.83 hectares of construction land and 224,074.21 hectares of ecological land. It had 229,000 people with 130,700 labours at the end of 2007. The economy developed rapidly, along with extensive highway and railway construction, despite being in one of the least developed areas of the Province. Nevertheless, problems relating to land use, population, resource and environment are becoming an increasing concern in a period of rapid economic development. Clearly, a development mode of "pollute first, improve later" would threaten the Provinces' ecological security. Therefore, Suichang County is a suitable vehicle for investigating DPZ-led land use changes and may provide a valuable reference for other regions with similar conditions.

Model validation

The model developed in the above section is calibrated with the data from Suichang County ranging over the 1999 to 2007 period. The model was validated through a feasibility analysis of its subsystems, sensitivity analysis and consistency analysis. The feasibility analysis showed that the simulated output of every subsystem is comparable with the historical data. A sensitivity analysis confirmed the robustness of the model, while the consistency analysis indicated the absolute value of relative error of 83% of the model's predictions to be within 5%, which implies that the model fits the historical data quite well.

Simulation of DPZ-led land use change

Zhejiang Province Development Planning & Research Institute (2007) policy suggests that Suichang County should be zoned as RDZ to achieve the aim of "protection first, develop moderately". The DPZ-led simulation also identifies the RDZ scenario as the most appropriate prioritization (Table 2).

<Insert Table 2 here>

With the RDZ scenario, eco-fragile farmland would be converted to forest land, while the land used intended for development would continue as farmland. Also, the model predicts an increase in ecological land area from 220,389.85 hectares in 2008 to 220,526.73 hectares in 2020. This annual increase rate of 0.01% from 2008 to 2020 is very large considering the annual decrease rate from 1998 to 2007 was 0.18%. The construction land area increased from 3878.53 hectares in 2008 to 3981.87 hectares in 2020, due to the predicted moderate development of eco-tourism, eco-agriculture and infrastructure. The annual increase rate of 0.22% from 2008 to 2020 is smaller than the 1.99% that occurred between 1998 and 2007. Thereafter, agricultural land area decreased from 30304.28 hectares in 2008 to 30064.06 hectares in 2020. The simulated annual decrease rate is 0.07% from 2008 to 2020 while the real increase rate was 1.27% from 1998 to 2007. This is caused partly by construction and partly by conversion from farmland to forest. The trend of land use change illustrated in Figure 9 matches the land use recommendations of the Zhejiang Province Development Planning & Research Institute (2007).

<Insert Figure 9 here>

Urban and rural construction land area increases from 3143.60 hectares in 2008 to 3186.29 hectares in 2020, which is slower than construction land area as shown in Figure

10. Moreover, the annual increase rate of 0.11% from 2008 to 2020 is much lower than the 1.4% from 1998 to 2007. This is mainly caused by the change of focus in economic development, which decreases the demand of urban and rural construction land. Moreover, the policy of “increasing vs. decreasing balance” would also help to control the total quantity of urban and rural construction land area while satisfying moderate urban construction land demand.

<Insert Figure 10 here>

Farmland area decreases from 15302.24 hectares in 2008 to 15093.97 hectares in 2020, due to construction use and conversion of eco-fragile farmland to forest. The annual decrease rate of 0.11% from 2008 to 2020 is much lower than the 1.41% from 1998 to 2007. Furthermore, the overall quality of farmland increases as the proportion of eco-fragile farmland and low quality farmland is reduced. The change in trend is shown in Figure 11.

<Insert Figure 11 here>

As shown by the land use change trend from 2008 to 2020, it is feasible to set the priority arrangement of D-U-H-P as HPUD to support the main function of RDZ. Led by DPZ, Suichang County should restrict development, leading to construction land control, farmland and ecological land protection. In this context, fiscal transfer should be used to balance the public services with social development.

CONCLUSIONS

This paper reviewed the strategy of development priority zoning (DPZ) and associated existing studies. Although land use policy is an important approach supporting DPZ, few studies quantitatively investigated DPZ-led land use change. As regional land use allocation is a complex dynamic system, this paper uses system dynamics to simulate DPZ-led land use change by examining the prioritization of land development, utilization, harness and protection (D-U-H-P). The identified D-U-H-P prioritisation is considered to be consistent with DPZ-led land use planning .

It is identified from the expert interviews that UHDP, DUHP, HPUD and PHUD is the most appropriate prioritisation for the optimized, key, restricted and forbidden development zones respectively. This is helpful in establishing the feasibility of system dynamics scenario simulation of each priority zone.

China’s central government has formulated a National Development Priority Zoning policy as the focus for the first national spatial plan (The State Council, 2010), which provides a very useful guide for land use planning policy. However, there is very little detailed guidance on how to implement this policy at the local level. As DPZ is led by the central government while land use planning is implemented and dominated by the local government, this paper creates a platform for communication between the two. The findings can therefore act as a useful guide for the local authorities in making appropriate land use plans.

Three major contributions from the systems dynamics scenario analysis arise from this study:

- It enables the local management authorities to simulate and explore future trends in land use change;
- It can provide quantitative guidance on land conversion, thus supporting the regulation of land use planning;
- It is able to examine the impact of land use policy and also help identify the most appropriate land use policies in support of DPZ strategy.

Future research needs to be focused on investigating and comparing the scenarios of UHDP under ODZ, DUHP under KDZ, and PHUD under FDZ. It can also be conducted to integrate the spatial analysis into the priority arrangement of D-U-H-P for different development priority zones. Possible extensions of the work also include using DPZ-led planning to help achieve improved sustainable land use.

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Table 1 Land use change and corresponding type of DUHP

Type of DUHP	Drivers	Land use change	Land use system conversion
Development (D)	Gap of farmland demand and supply (resource subsystem), dynamic balance in farmland (main land use system),	other agriculture land(e.g. horticultural land) →farmland	Agriculture land →Agriculture land
		Forest →farmland	Ecological land →agriculture land
	dynamic balance in farmland (main land use system)	Unused land →farmland, other agriculture land(e.g. horticultural land)	Ecological land→ Agriculture land
	Population growth (population subsystem), economic development (development subsystem)	farmland, other agriculture land →urban and rural construction land, other construction land	Agriculture land→ construction land
		Forest, unused land →urban and rural construction land, other construction land	Ecological land→ construction land
Use(U)	People-land intension, optimization	No change	No change
Harness (H)	The balance of farmland requisition-compensation (land use main-system), balance of urban and rural construction land (land use subsystem)	rural residential land, remaining construction land →farmland	Construction land→ Agriculture land
	dynamic balance in farmland (main land use system), incentive for fiscal transfer (development subsystem)	Other agriculture land →farmland	Agriculture land →Agriculture land
Protection (P)	Threshold of ecological services (environment subsystem),	farmland →forest, pasture, water	Agriculture land→ ecological land

Note: The land is divided into agriculture land, construction land and ecological land. The information about the land use system classification is listed in the appendix 1

Table 2 land use change under HPUD and restricted development zone for Suichang

year	Agriculture land (ha)	Construction land (ha)	Ecological land (ha)	Farmland (ha)	Urban and rural construction land (ha)	Quality of farmland
initial	30330.75	3870.21	220371.70	15326.03	3140.66	1.1575
2008	30304.28	3878.53	220389.85	15302.24	3143.60	1.1574
2009	30280.79	3888.07	220403.79	15281.83	3147.65	1.1571
2010	30258.63	3897.74	220416.29	15262.95	3152.15	1.1570
2011	30240.17	3906.91	220425.58	15247.75	3156.24	1.1567
2012	30221.92	3916.19	220434.55	15232.67	3160.38	1.1566
2013	30203.86	3925.32	220443.48	15217.66	3164.34	1.1565
2014	30185.28	3934.25	220453.13	15201.75	3168.08	1.1576
2015	30166.61	3942.98	220463.07	15185.52	3171.66	1.1587
2016	30146.88	3951.60	220474.19	15168.35	3175.18	1.1598
2017	30126.63	3959.87	220486.16	15150.47	3178.43	1.1611
2018	30106.07	3967.66	220498.93	15132.13	3181.34	1.1624
2019	30085.20	3975.00	220512.46	15113.30	3183.95	1.1636
2020	30064.06	3981.87	220526.73	15093.97	3186.29	1.1650

Strategy of development priority zoning

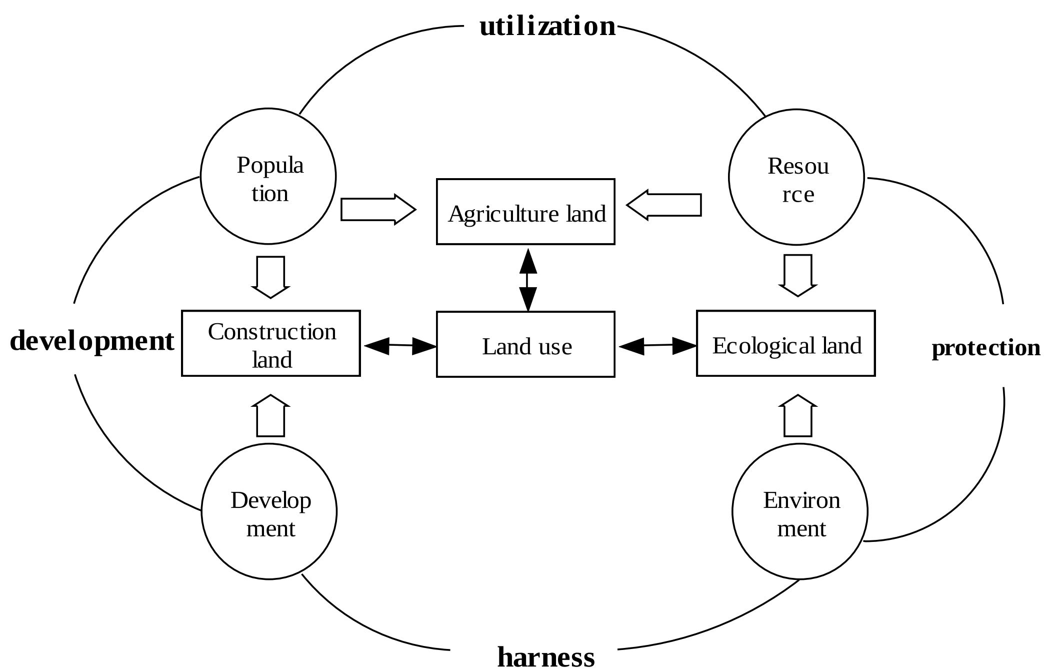

Figure 1 Conceptual model of regional land use guided by development priority zoning

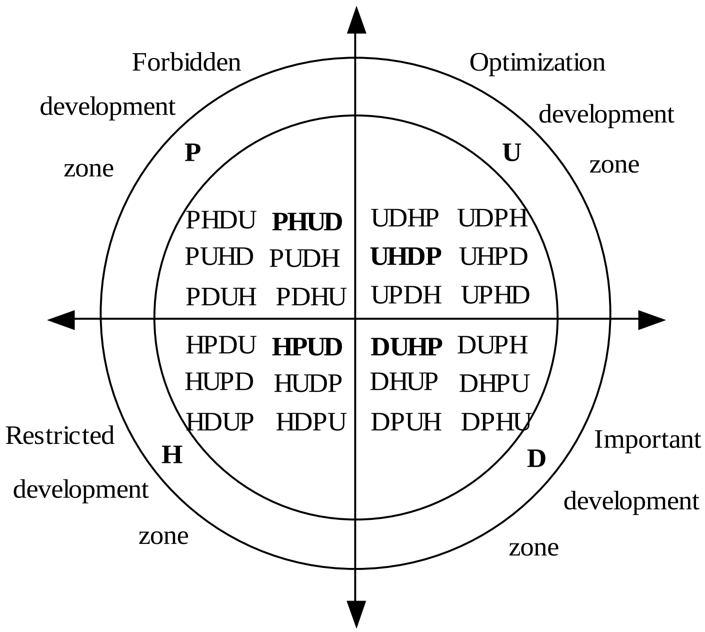

Figure 2 potential combinations of DUHP under development priority zone

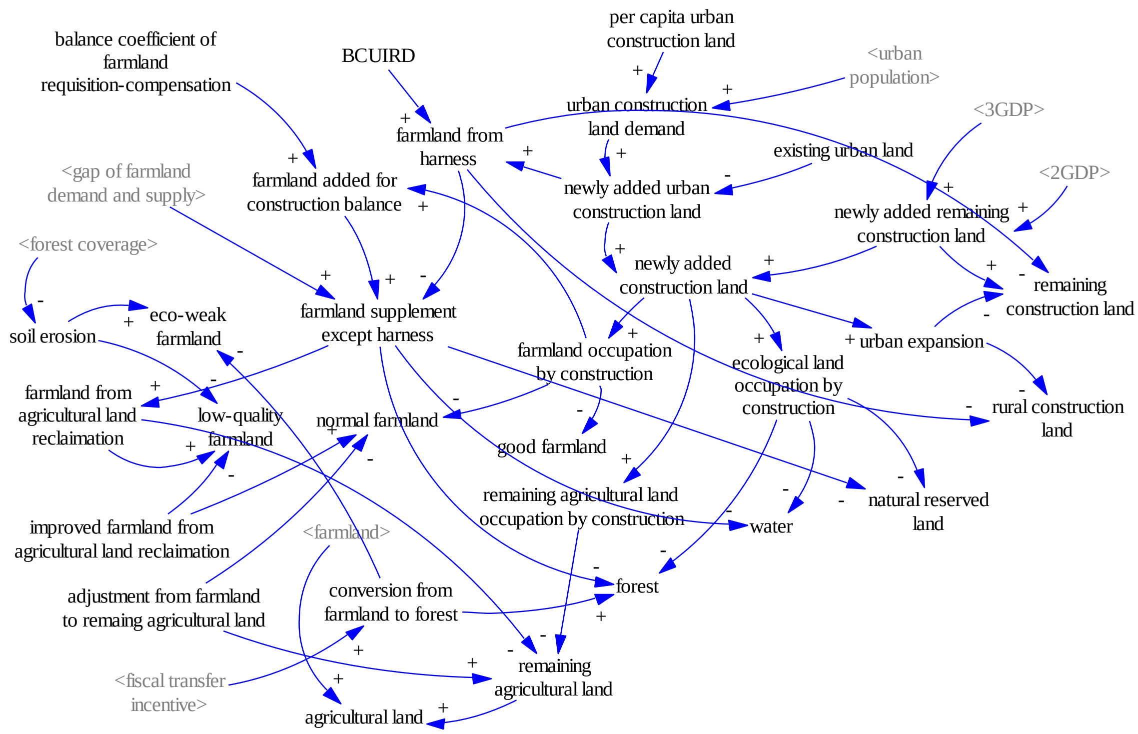

Figure 3 An illustration of the causal relationship of land use main-system

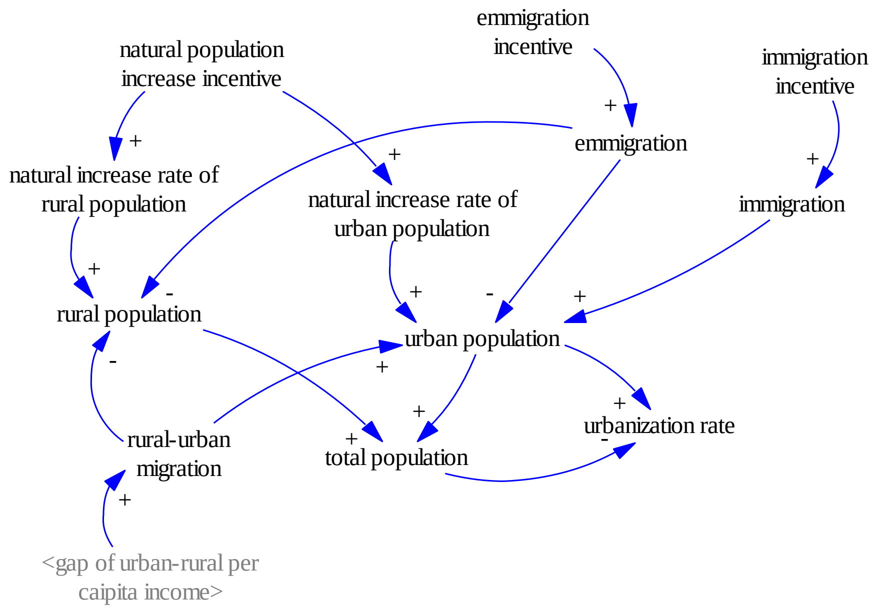

Figure 4 An illustration of the causal relationship of population subsystem

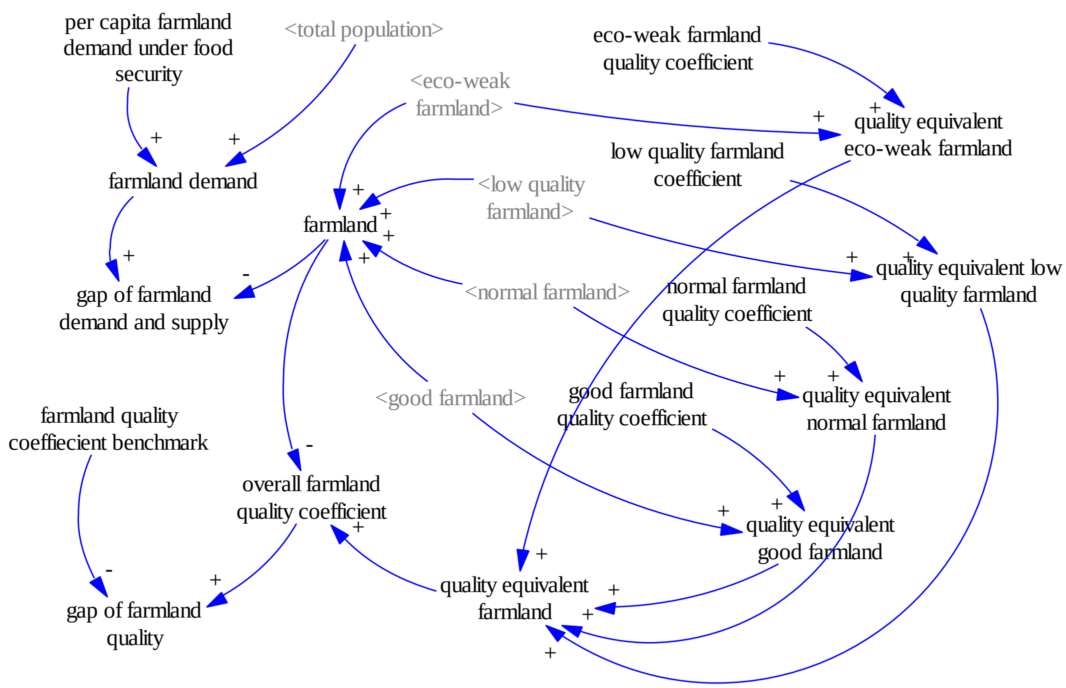

Figure 5 An illustration of the causal relationship of resource subsystem

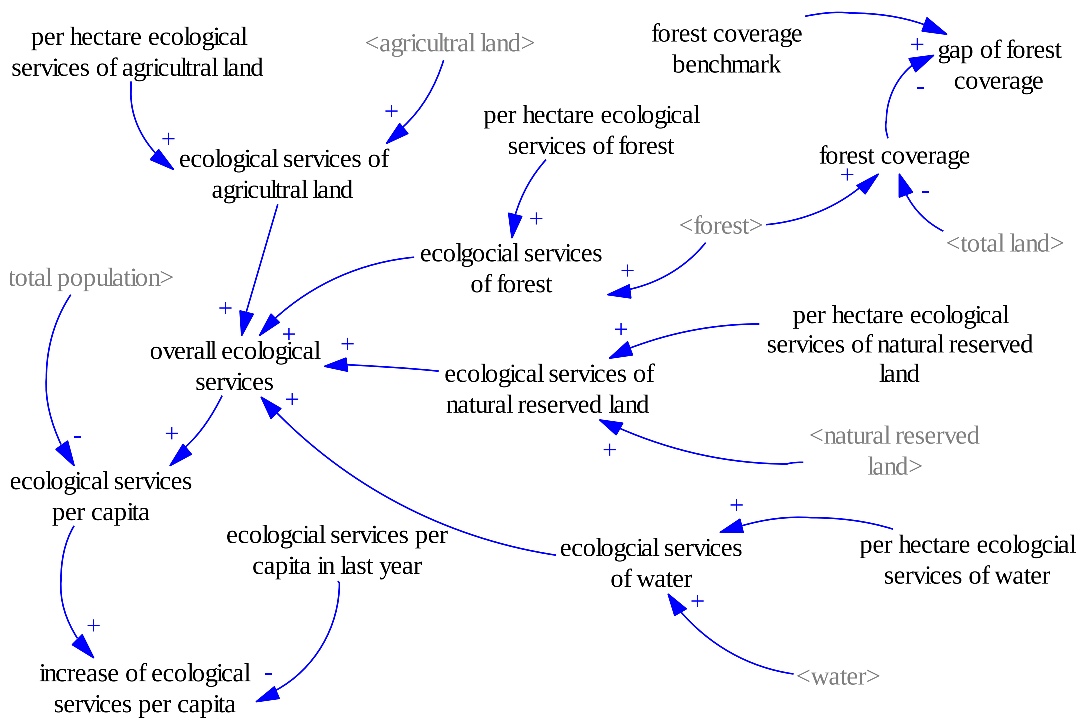

Figure 6 An illustration of the causal relationship of environment subsystem

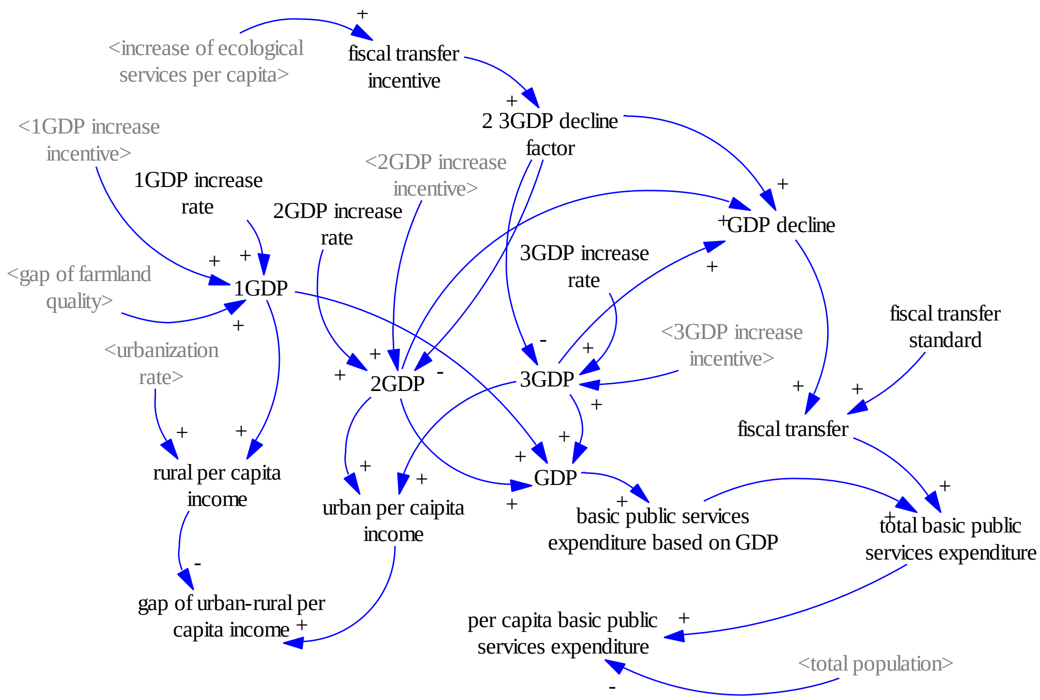

Figure 7 An illustration of the causal relationship of development subsystem

Figure 8 The location of Suichang County in China

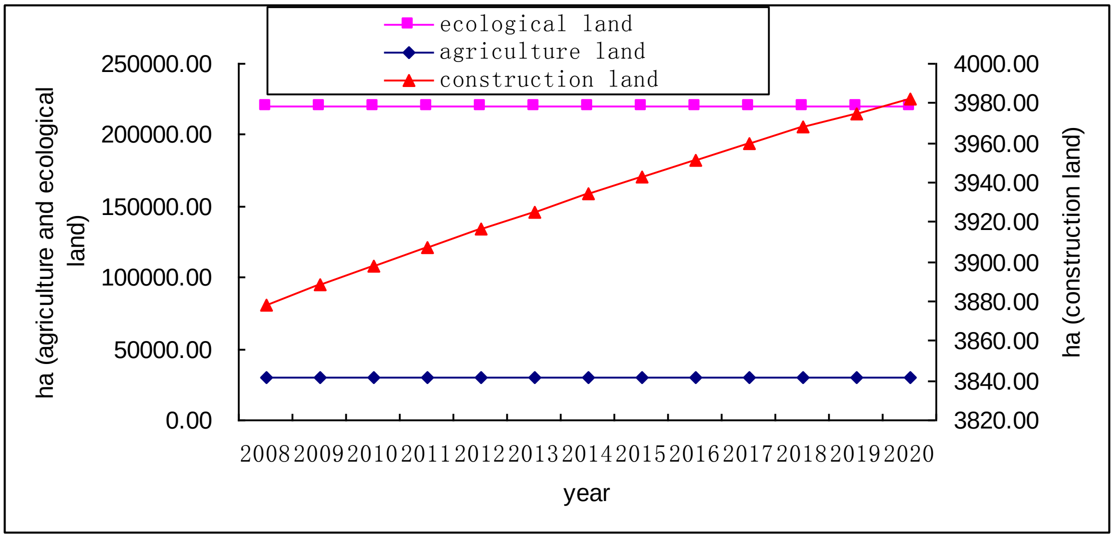

Figure 9 The land use structure under HPUD and restricted development zone in Suichang

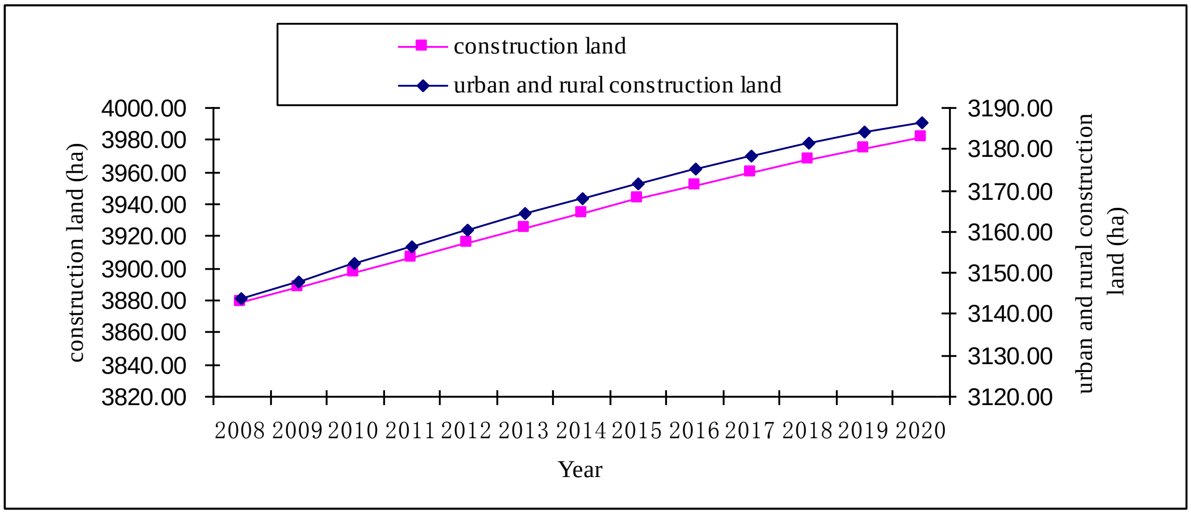

Figure 10 The comparison of construction land, urban and rural construction land under HPUD and restricted development zone in Suichang

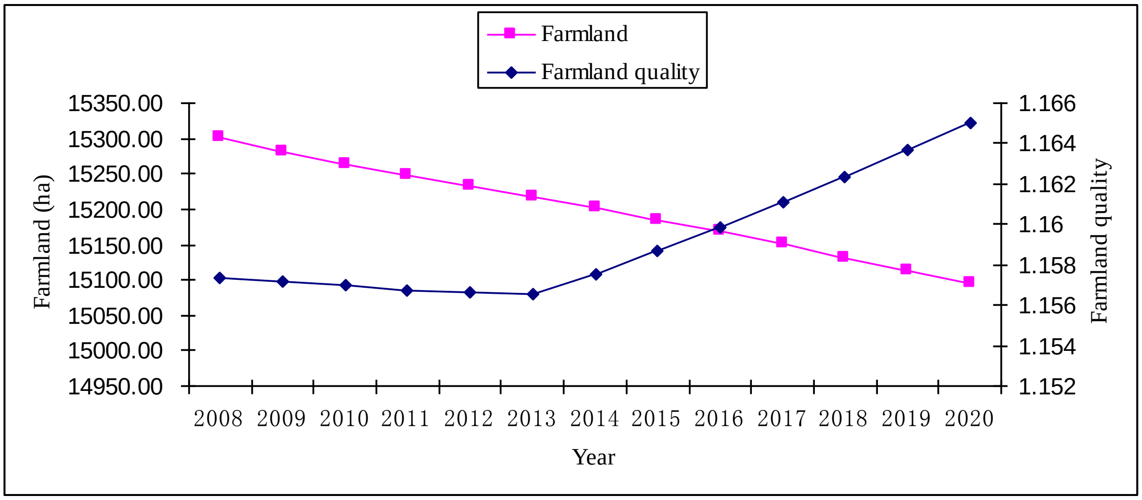

Figure 11 The comparison of farmland and quality of farmland under HPUD and restricted development zone in Suichang

Appendix 1 The classification system of land

Main Type	Sub Type	Explanation
Agricultural land	Farmland	
	Other agriculture land	Horticultural land
		Other land for agricultural purpose
Construction land	Urban and rural construction land	Urban construction land
		Rural construction land
	Other construction land	Salt land
		Specially used land
		Railway land
		highway land
		Airport
		Port
		Pipeline transport land
		Hydraulic architecture
Ecological land	Forest	
	Grassland	e.g. Natural and artificial grassland
	Water	Reservoir
		River
		Lake
		Reed land
		Beach
	Unused land	e.g. sandy land, desert, saline land, bare land, glaciers, and permanent snow

Note: Suichang County has no grassland

Appendix 2 The stock-flow diagram of land use guided by development priority of zoning